Deriving ocean surface currents from remote sensing techniques

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SR3 section

Assimilation:
- temperature
- salt
- velocities
Transport across section: $159 \pm 64 \text{ Sv}$

Formal errors: Inverse of the Hessian of the cost function.
Mean dynamic topography

- geostrophic balance: \( \frac{\partial \eta}{\partial x} = \frac{f}{g} v \Rightarrow \) reference surface velocity
- \( \eta = h - N \)
Problems with the geoid!

- Geoid models describe short scales not sufficiently for oceanography.
- Omission error is generally neglected $\Rightarrow$ underestimation of the geoid model error.
- “Higher” accuracy $\Rightarrow$ larger formal error.
- Considering omission error $\Rightarrow$ “complete” geoid models.

Is it possible to improve the ocean models by assimilating MDT?
Principle for omission error problems

Homogeneous, isotropic covariance function for geoid model

\[ C'(\psi) = \sum_{l=0}^{L} p_l P_l(\cos \psi) = \sum_{l=0}^{L} p_l \sum_{k=0}^{l} a_{lk} \cos k\psi = \sum_{k=0}^{L} c_k \cos k\psi \]

with the (Fourier-) coefficients

\[ c_k = \sum_{l=k}^{L} p_l a_{lk} \]
Ocean model parameters

Free to choose:

- discretization method
- number of iterations
- bottom (reference) velocities
- roughness parameters for salinity, temperature, horizontal velocities
- prior error estimations

\[ \sim \text{Transport across section: } 174 \pm 48 \text{ Sv} \]
Transport error estimates

- No MDT
- Omission error neglected
- Omission error partly considered
- Full omission error
Stationary 3D model: IFEOM
Inverse box model for the Southern Ocean

e.g. Sloyan and Rintoul (2001), Losch, Sloyan, Schröter and Sneeuw (2002)
Ice drift algorithm

\[
\begin{bmatrix}
\bar{c}_u \\
\bar{c}_v \\
\end{bmatrix}
= 
\begin{bmatrix}
\bar{U} \\
\bar{V} \\
\end{bmatrix}
- F \cdot 
\begin{bmatrix}
\cos \theta & - \sin \theta \\
\sin \theta & \cos \theta \\
\end{bmatrix}
\begin{bmatrix}
\bar{u} \\
\bar{v} \\
\end{bmatrix}
\]

Turning angle: \( \theta = \arctan \left[ \frac{\sum u' V' - \sum v' U'}{\sum u' U' + \sum v' V'} \right] \)

Speed reduction factor:

\[
F = \frac{\cos \theta \sum u' U' + \sin \theta \sum v' U' - \sin \theta \sum u' V' + \cos \theta \sum v' V'}{\sum u'^2 + \sum v'^2},
\]

\( u' = u - \bar{u} \) etc.

(N. Kimura: Sea Ice Motion in Response to Surface Wind and Ocean Current in the Southern Ocean, JMSJ 2004.)
Ice drift and wind data

5~cm/s

5~m/s
Resulting ocean surface currents

Mass transport across section:

\[ 173 \pm 46 \text{ Sv} \]
Mass transport across section for the 3 cases:

Ocean model only: \(159 \pm 64\) Sv
Ocean with dynamic topography: \(174 \pm 48\) Sv
Ocean with drifting sea ice: \(173 \pm 46\) Sv
Thank you for your attention!

? Questions ?